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Fruit Cold Storage Environment Monitoring System Based on Wireless Sensor Network

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Abstract

In recent years, wireless sensor network (WSN) is increasingly applied in the field of environmental monitoring due to its promising capability. Focused on the monitoring of fruit cold storage, this paper constructed a wireless sensor network based on ZigBee protocol. The design scheme of sensor node and sink node were described in detail. Chip CC2430 with ZigBee technology was considered as the core of information processing and wireless nodes detection. Through sink node as well as integrating wireless mobile network (CDMA), acquired data was sent to database server on control center. Experiment results show that the working performance of the system is quite stable and can reach the design requirements in real-time data acquisition and remote control. Furthermore, the system has the characteristics of good expansibility, networking flexibility and low cost. The design gives a new way to collect the data of environment instead of the traditional way using wires or manually.

Keywords: wireless sensor network; cold storage; environment monitoring

1. Introduction

In fruit cold storage, the temperature [1], humidity [2], the concentration of carbon dioxide [3] and ethylene [4] are the primary factors that affect the fruit storage expiration. The most important thing for manager is to master the cold storage condition in time, and then effective measures were taken.

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Generally, the fruit storages are built in suburban adjacent to producing areas, which causes great management inconvenience. Therefore, it has great realistic meaning to improve the management efficiency using automatic monitoring system. The large fruit cold storage always occupies thousands of square meters and must be adapt to different fruit in different seasons. Storage reusability requires that the sensor location often needs to be moved and a traditional wire layout will cost a great deal of time. As a novel information acquiring and processing technology, wireless sensor networks (WSN) have many advantages, such as self-organization, low cost, low power consumption, flexible deployment, wide coverage, and so on, which make it widely applied ranging from military field to many civil fields [5-7]. Although a great progress has been made in many research and application filed, little is concerned about its application in monitoring cold storage.

In order to resolve the changeable problems mentioned above, a design of monitor system for cold storage based on wireless sensor network is proposed in this paper. A tiered architecture of the WSN-based monitor system used for storage is discussed firstly, and then the detailed design of the system is given including hardware and software of sensor node and sink node.

2 System architecture

As is shown in Fig. 1, a network structure is proposed. The architecture of the cold storage environment monitoring system based on wireless sensor networks consist of the common sensor nodes, sink nodes, control center and communications system. A large number of the sensors can be placed in the storage and constructed a self-organized network to monitor the data change including temperature, humidity and gas concentration, etc. To perform a complete and accurate environment monitoring, it is significant to introduce image and video into sensor networks system in some applications [8, 9]. Thus, image devices can be optionally equipped according to the need of application and the cost limitation. The common nodes will collect the data which transmitted to the sink node. The data is delivered by sink node and stored in the database on control center. The control center can send the control information to any node in the network. Likewise, the remote data could be transmitted to the control center with the sink node. That means sink nodes act as the media of the communication between common nodes and control center, and it can not realized to directly send message between them. We used a CDMA modem to connect the wireless sensor network to the Internet, and then any authorized users can access the data through browser. In this architecture, only one public IP address is required for a sink node zone.

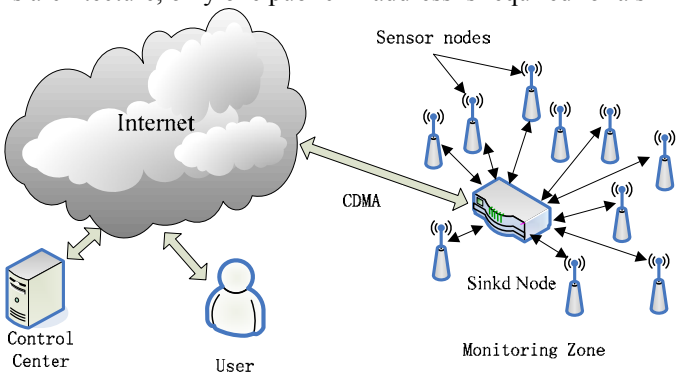

Fig. 1 System architecture

3 Hardware design of the system

Sensor node is the basic platform of wireless sensor networks. The sensor node consists of five parts, sensor module, Analog/digital (A/D) conversion module, processing module, wireless communication module and the power module. Sensor module is used to collect temperature, humidity, gas concentration and other parameters. Analog/digital conversion module can convert analog signal comes from sensor module to digital signal which can be recognized by processor unit. The processor module controls the operation of the sensor nodes, stores and processes the collected data, as well as simple computation and analysis. Wireless module communicates with sink nodes, exchanges control information, sends and receives data. In this paper, wireless communication module is based on ZigBee technology, which is the set of specs built around the IEEE 802.15.4 wireless protocol. ZigBee devices in a network can communicate at speeds of up to 250Kbps while physically separated by distances of up to hundreds of meters in typical circumstances and greater distances in an ideal environment. Based on ZigBee network communication technology and microprocessor technology, the system can deal with the various operating parameters of the remote transmission, real-time data collection and real-time monitoring. The power modular provides the energy to the sensor module, A/D conversion module, processing module and wireless communication module. The hardware structure of the node is shown in Fig. 2.

As the most important part of a sensor node, processor and wireless chip exploits CC2430. The chip includes 2.4GHz RF transceiver and an industry-standard enhanced 8051 MCU, 32/64/128 KB flash memory, 8 KB RAM and many other powerful features. Thus it can content the need of high performance and low power in 2.4 GHz IEEE 802.15.4 band based ZigBee.

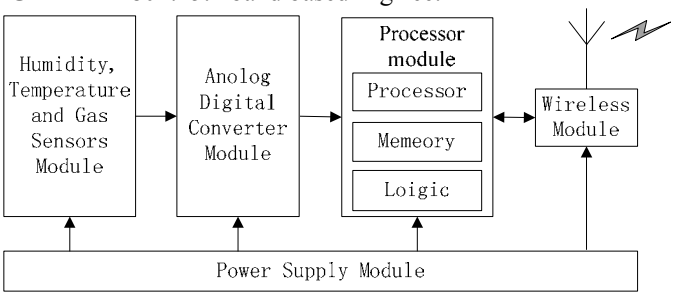

Fig. 2 The block chart of sensor node

The data integration, positioning algorithm and other complex computation are completed by sink node, so a more advanced processor is needed. Samsung's 16/32-bit RISC microprocessor S3C2440 is suitable for these tasks. It is designed to provide hand-held devices and general applications with low-power, and high-performance microcontroller solution in small die size. The S3C2440A is developed with ARM920T core, 0.13um CMOS standard cells and a memory complier. It adopts a new bus architecture known as Advanced Micro controller Bus Architecture (AMBA). The ARM920T implements MMU, AMBA BUS, and Harvard cache architecture with separate 16KB instruction and 16KB data caches, each with an 8-word line length. Its low power, simple, elegant and fully static design is particularly suitable for cost- and power-sensitive applications.

4 Software design of the system

The software architecture of sensor node is divided into embedded operating system kernel layer and API layer. The kernel also provides a low-level node driver of all hardware devices. API layer provides sensor acquisition module and RF communication module. Embedded operating system TinyOS serves as the software platform of the nodes, which is an open-source operating system designed for wireless embedded sensor networks. The TinyOS system, libraries, and applications are written in nesC, a C-like language optimized for the memory limitations of sensor networks. The nesC language supports the

TinyOS concurrency model, as well as mechanisms for structuring, naming, and linking together software components into robust network embedded systems. Task debugging module controls the control flow throughout the operating system, which is mainly responsible for the initialization of the wireless sensor and the maintenance of the operating status. The power management module supports processor, RF transceiver, sensors and other parts of the state control of energy consumption. Energy management is able to ensure that nodes wake up at the right time, run in the low-power mode and maximize the use of energy. The software flowchart of sensor node is shown in Fig. 3. The program initializes CC2430 firstly, then opens the power of sensor and initialize protocol stack, begins send signal to add to network, waits for network coordination's answer and assigns network address.

As to sink node, the CC2430 is also initialized firstly, then the protocol stack is initialized and the interrupt is opened. After that program began formatting the network, if the network is formatted successfully, and sink node connect to computer by serial port, we can find the physical address, network ID and channel number by software, and then sink node is in monitoring state. If a sensor node try joining the network, sink node will assign a network number. If data collection node sends some data, it will judge where the data comes from, and sends the message to control centre. The software flowchart of sink node is shown in Fig. 4.

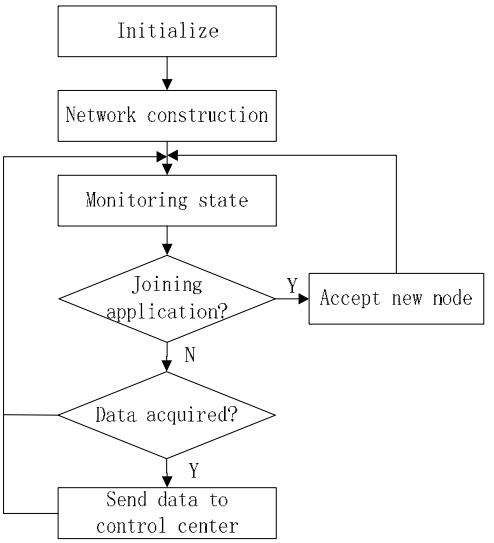

Fig. 3 The software flowchart of sensor node

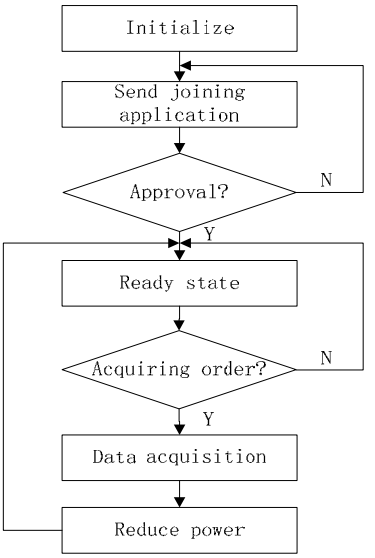

Fig. 4 The software flowchart of sink node

5 Conclusions

It is significant to effectively manage the stored fruit in cold storage using electronic and information technology. In this paper, the design and implementation of a novel scheme for environment monitoring system is introduced based on wireless sensor network. Compared with the traditional method, the advantages of the system can be summarized as follows.

(1) The data can be acquired automatically, which promote the management efficiency greatly.
(2) The data can be stored.
(3) Communication function of the system provides the storage manager remote control ability.

The advantages above-mentioned make the system more practicable and promising. Further quantitive experiments and evaluation of the system are the topics of our future study.

References

[1] Holland N., Menezes H. C., Lafuente M. Carbohydrates as Related to the Heat-Induced Chilling Tolerance and Respiratory Rate of 'Fortune' Mandarin Fruit Harvested at Different Maturity Stages. *Postharvest Biology and Technology*, 2002; 25(2): 181-191.

[2] Alquezar B., Mesejo C., Alferez F., et al. Morphological and Ultrastructural Changes in Peel of 'Navelate' Oranges in Relation to Variations in Relative Humidity During Postharvest Storage and Development of Peel Pitting. *Postharvest Biology and Technology,* 2010; 56(2): 163-170.

[3] Liu S., Yang Y., Murayama H., et al. Effects of CO2 on Respiratory Metabolism in Ripening Banana Fruit. *Postharvest Biology and Technology*, 2004; 33(1): 27-34.

[4] Kan J., Wang H. M., Jin C. H., et al. Changes of Reactive Oxygen Species and Related Enzymes in Mitochondria Respiratory Metabolism During the Ripening of Peach Fruit. *Agricultural Sciences in China*, 2010; 9(1): 138-146.

[5] Meng-Shiuan Pan; Lun-Wu Yeh; Yen-Ann Chen. A WSN-Based Intelligent Light Control System Considering User Activities and Profiles, *IEEE Sensors Journal*, 2008; 8(10): 1710-1721.

[6] Shilong Lu; Xi Huang; Li Cui. Design and implementation of an ASIC-based sensor device for WSN applications, *IEEE Transactions on Consumer Electronics*, 2009; 55(4):1959-1967.

[7] Alippi, C.; Camplani, R.; Galperti, C. A Robust, Adaptive, Solar-Powered WSN Framework for Aquatic Environmental Monitoring, *IEEE Sensors Journal*, 2011; 11(1):45-55.

[8] Semertzidis, T.; Dimitropoulos, K.; Koutsia, A. Video sensor network for real-time traffic monitoring and surveillance. *Intelligent Transport Systems*, 2010; 4(2):103-112.

[9] Akyildiz, I.F.; Melodia, T.; Chowdury, K.R. Wireless multimedia sensor networks: A survey, *IEEE Wireless Communications*, 2007; 14(6)6: 32-39.